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length; near its northern end Dar-es-Salaam, the chief port of the coast, lies on a fine harbor embayment; the town of Zanzibar, not far away to the north, has a reef-enclosed harbor on the western side of its island.

The fivefold division of the coast, just described, is the most profitable physiographic lesson of Werth's book. It is given belated statement in the first part of the second volume. The above explanation of it by down-warping in association with the emergence of the elevated reef, as well as the changes of level inferred from the sandy and loamy deposits which occupy the valleys of the uplands and which are themselves trenched by narrower and partly embayed valleys, are based more on the geological map than on the text; but the map indicates them so clearly that the absence or obscurity of text statements concerning them is not easily understood. On the other hand, a redundant treatment of the abrasional features along the advanced coast is also difficult to understand; they are described first under "Küstenterrassen" on pages 22 to 24 and again under "Strandterrassen" on pages 49 to 51. One bite at that sort of a cherry should suffice. But there is, without question, a large body of physiographic information contained in the two volumes; and if the other chapters are as richly stored as the one here reviewed they are well worth working.

The book appears to have been prepared about the time the World War began and was published during its progress. It is dedicated to those who had already lost their lives in defending German possessions in East Africa. The coastal belt was selected for description because of its great importance in the further development of the colony. The many pages must, therefore, be sad reading to German readers under present conditions; but they must be of high value to the mandatary in whose charge the colony has been placed.

W. M. Davis

Dunes and Dune Formation

W. Behrmann. **Borkum: Strand- und Dünenstudien.** 40 pp.; map, ills. *Meereskunde No. 153* (= Vol. 13, 1919, No. 9). Berlin.

Borkum, a well known bathing resort, situated at the mouth of the Ems, nine miles from the Dutch coast and between the channels called the Oster Ems and Wester Ems, is the westernmost of the East Frisian Islands. The island has grown together from two islands, which are even now so clearly indicated that they bear the distinctive names of Eastland and Westland. The small Eastland lies north of the larger Westland and is not so greatly exposed to the winds and waves as the latter. The islands were separated from each other from time to time up to 1863. Since then they have been joined by a dike, and the dunes on the north have been made artificially and ingeniously for the reinforcement of this dike. At some time sand comes to the island from all sides except the east, where there is a sand-clay flat. The waves and the tides tend to beat and to scour material from the west end and to drive it toward or to this sand-clay flat. But there are high dunes on the west and also a beach wall almost four kilometers long which protects the land from the violent beating of the waves. Before this wall was built the breakers had already reached the dunes; and there is a steady westward movement of the sands along shore which has formed and maintains the "Hohe Hörn." This movement of the sand of Borkum is like that of all the Frisian Islands, to the east. The Eastland, however, is not so strongly swept and scoured by the winds, waves, and tides as the Westland. The sand level on the North Strand is wonderfully maintained through the protective effect of the great horseshoe-shaped dune which covers a large part of Eastland.

The author discusses in detail the formation of rill- and ripple-marks on the beach, as well as the deeper channels that occur in front of the breakers; and he describes the occurrence of beach potholes, made by the fall of the stronger breakers, and the formation and breaching of beach walls. The incoming waves and tides normally bring in much more material to the shore than is carried away by the ebb, and in this way a beach wall 80 to 100 meters broad and 1½ meters high has been built up between the beach flats and the sea. The beach flats are growing in the east and breaking down in the west. One may observe on a portion of Borkum the base level due to deflation, and every phase of the work of wind and wave is here observed and described.

"The side on which the wind allows plants to grow promotes upbuilding and encourages animal and human life. The fowl world of the inner side is entirely different from that on the side exposed to the open sea. In the meadows struts the plover, the lapwing cries, and the crested lark rejoices; the beach bird shows himself only on stormy days, and in the protection of the dune. . . . The inhabitants use driftwood for fuel and building. Close by or between the dunes in the vicinity of the sea lie the little houses of the fishermen." The paper is a study of shore-line processes in relation to biogeography.

COLLIER COBB

ÉDOUARD HARLE AND JACQUES HARLÉ. **Memoir sur les dunes de Gascogne, avec observations sur la formation des dunes.** Extrait du *Bulletin de la Section de Géographie, 1919*, pp. 145. Paris, 1920.

The senior author of this interesting paper has previously published nine papers on different phases of the geology or geography of Gascony, one of which, "La fixation des dunes de Gascogne," was noticed in the *Geographical Review* for November, 1916. The two authors, father and son, have previously published, in collaboration, "Les dunes continentales des landes de Gascogne" and "Les dunes maritimes de la côte de Gascogne."

The dunes of Gascony, those of the interior as well as those that border the ocean, are very numerous, and those along the coast are the most considerable in Europe. Save for some very rare exceptions, those next the ocean are all covered with forests which are completely fixed. One rarely sees these dunes actually move, and many of the authors' conclusions are therefore deductions drawn from what has been told them about the now immovable dunes. The studies in each case deal with observations that have actually been made by someone up to this time. In certain cases the authors give no explanations of the observed phenomena, and in others they express doubt as to the explanations that they do give. The hope is expressed that even if what is set forth is incomplete and lacking in clearness, it will serve "to provoke someone to more careful study."

The account is illustrated with numerous plans and sketches which make clear the authors' explanations and give one an excellent idea of the country.

The paper then proceeds to a geological description of the country, which much resembles our own Atlantic coastal plain. The origin of the sands of the *landes*, that is their source and manner of transportation, is very obscure; but the author is inclined to accept the view expressed by Glayac that the sands have been brought from the land by the rivers, which have wandered much in their courses over the plain, and have been thrown up from the sea by the waves and driven inward by the winds. He objects to this explanation, however, on the ground that the material is very fine, and he would expect the river to bring down stones of considerable size, and the waves of the sea to throw up something of the same sort. The Garonne and Adour actually do transport fair-sized stones, and the sea is now actually depositing stones of some size on the borders of the *landes*.

An excellent and somewhat detailed description of the surface of the district is given, with some account of the agglomerated sand, known locally as *alios*, a hardpan which exerts a marked influence on the drainage and water table of the district.

Unlike previous studies of the region, this paper treats not only of the maritime dunes, but of the continental dunes as well, dividing these latter into dunes of the plateaus and dunes of the valleys. The authors here present a most interesting discussion of the origin of the parabolic dunes, where the wind has hollowed out the concave side. They have moved in a direction exactly opposite to that of the wind, which has formed and is now driving forward the *medanos* or *barchanes* in our own interior, or the whale heads on Currituck. The authors show one such form (termed *caoudeyre*) from the commune of Pissos, in which the hollowing is done by the wind moving in the direction of the horns of the crescent. These parabolic dunes owe their form to the erosive action of the wind, and in this they differ essentially from *barchanes*, which are due to constructive action, and these latter are evidently unknown to our authors in their district.

The *étangs*, lakes formed by dune action hindering drainage, are described, and the later formation of dunes on the shores of these lakes is indicated.

The sands composing the dunes, the differences between the ancient and the modern dunes, and the changes in the forms of the modern dunes produced by fixation, are all considered with much care.

The movement of dunes in waves, a phenomenon well-marked on our own Atlantic coast, is here noted, and the last section of the brochure is devoted to a discussion of the theory of such movements.

The bibliography is good but needs some additions. A detailed index would add to the usefulness of the paper. This paper, together with the account of the Borkum dunes, may well be taken as a model for future studies of dune areas.

COLLIER COBB

A TEXTBOOK OF SEISMOLOGY

CHARLES DAVISON. **A Manual of Seismology.** xi and 256 pp.; maps, diagrs., ills., index. (Cambridge Geological Ser.) The University Press, Cambridge, 1921. 8½ x 6 inches.

Dr. Davison's contributions to the study of earthquakes are well known, and we welcome this volume from him. His "aim has been to give an outline of our present knowledge" of the subject; and this he has accomplished very well. He has given clear accounts of the principle of seismographs, of the nature of earthquake motion, of the propagation of the disturbance, of the geographical distribution of earthquakes—in short, of earthquake phenomena in general. Students of seismology will miss a discussion of the underlying principles of the subject and of its many still unsettled problems; but the length of the book and the general purpose of the series to which it belongs make this impossible. A few ideas are expressed with which the reviewer does not agree; for instance, Davison's conceptions of twin earthquakes. He supposes two fractures of the rock, at points not far apart, to take place within an interval of time so short that the second fracture could not be influenced by the vibrations from the first. Much stronger evidence than we have is necessary to establish so improbable a coincidence. In common with some other seismologists he thinks the buckling of railroad lines in Baluchistan at the time of the earthquake in 1892 indicated a compression of the earth's crust; whereas it was shown in the report of the California earthquake of 1906 that the movement on the fault caused just such an apparent compression without any reduction of the area of the region. Davison regards the first appearance of seismic sea waves at the shore as a depression of the water; this is certainly very general, but there are many instances where the elevation of the water occurs first. The destructive effects of earthquakes on houses and other structures are not treated, probably for lack of space and because these effects may be considered as belonging to applied seismology rather than to the pure science itself.

HARRY FIELDING REID

A NEW ESTIMATE OF OCEAN DEPTHS

ERWIN KOSSINNA. **Die Tiefen des Weltmeeres.** 70 pp.; diagrs. *Veroffentl. des Inst. für Meereskunde*, N. F., A. (Geographisch-naturwissenschaftliche Reihe), Heft 9. E. S. Mittler & Son, Berlin, 1921. 10½ x 7 inches.

This is the latest of the many attempts to estimate the mean depth of the ocean. There are no new methods devised, but the work has evidently been very painstaking, and the results are probably very near the truth. Groll's equivalent-area maps of the oceans, corrected by additional observations made since they appeared, are the basis of the work. The method used was to print Groll's bathymetric lines on paper ruled to square millimeters, and to count the number of square millimeters between successive lines, estimating to tenths. This was done for areas 5° on the side, over all the oceans, and checked by counting the millimeters in each area as a whole. The area corresponding to one square millimeter was not determined by the scale of the map, but by dividing the area between the bounding parallels and meridians, as calculated on a Bessel's spheroid, by the total number of square millimeters counted in it. By this means errors due to inaccuracies in ruling the paper, or to shrinkage or expansion, were avoided. The errors that could not be avoided are due to inaccuracies of the maps and to lack of data for even large areas of the oceans, but it is not likely that Kossinna's results will be materially affected when these deficiencies are made up. The mean depth that he deduces for all the oceans is 3,800 ± 100 meters, somewhat greater than the best estimates made earlier. His measures can evidently be used for other purposes; for instance, to determine the ratio of land and water on the globe. This he finds to be 1 : 2.43; agreeing with Krümmel and differing somewhat from Wagner (1 : 2.54). He also applies his measures to find the ratio of land to water in the northern and southern, the land and the water, hemispheres, and to determine the areas and mean depths of all the oceans and seas of the earth. He combines with